Pratap Bhanu Solanki

Curriculum Vitae

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Professional Summary

I pursued my Doctoral research at Smart Microsystems Lab, Michigan State University. My research work centered around wireless LED-based optical communication for underwater robotic systems. In particular, I worked on developing robust alignment control algorithms to establish and maintain the required line-of-sight for communication. I have a balance of both theory and experiments in my research work, where I bring the two together by deploying my strong software and hardware engineering skills. My broad area of research interests includes design, modeling, simulation, and control of autonomous robots, with tangential interests in computer vision, advanced AI, and machine learning algorithms.

Education

- **Michigan State University (MSU)** East lansing, MI
  Ph.D. in Electrical Engineering; GPA 3.97/4 *Aug. 2014 – April 2021*
  Dissertation: *"Alignment Control for Optical Communication between Underwater Robots"*
  Primary Advisor: Dr. Xiaobo Tan
  Committee Members: Xiaobo Tan (chair), Dr. Hassan Khalil, Dr. Ranjan Mukherjee, and Dr. Daniel Morris
  GPA: 3.97/4

- **Indian Institute of Technology (IIT) Kanpur** Kanpur, India
  Bachelor of Technology in Electrical Engineering; CPI: 8.5/10.0 *Aug. 2009 – May. 2012*
  Major Project: *"Design, Development and Simulation of a Robotic Fish"*
  Project Mentor: Dr. Laxmidhar Behera
  CPI: 8.5/10

Industry Experience

- **Facebook Reality Labs (Oculus Research)** Redmond, WA
  Summer Research Intern *May 2018 - August 2018*
  - **Eye Tracking:** Developed and simulated a model of an underlying system of Eye Tracking team.
  - Used non-linear optimization techniques for calibrating hardware parameters of the involved system. (Specific details are omitted due to non disclosure agreement (NDA) with the company)
- **Housing.com** Mumbai, India
  Software Developer *June 2013 - July 2014*
  - Built web applications on **Ruby on Rails**, catering the operational needs of company
  - **Real-time Job-assignment:** Developed a dashboard for customer care and operations team which allows automated real-time job-assignment. Used Google Maps API to estimate and optimize travel time of multiple data-collector agents spread across a city
  - Stimulated a significant operational productivity and efficiency boost over 8 locations across India by deploying the automated job-assignment system to production

Research and Engineering Projects

- **Alignment control in 3D space for Underwater Optical Communication** East Lansing, MI
  Mentor: Dr. Xiaobo Tan, Michigan State University *May 2015 - Present*
  - Designed and developed an active alignment control based LED-optical-communication system.
  - Mathematically formulated a system of two transceive as a dynamical system to enable real-time *state-estimation* and alignment of *azimuthal* and *elevation* angle errors with line-of-sight (**LOS**) orientation.
  - Introduced 3D-scanning techniques bring to full-**observability** to the otherwise partially-observable system.
  - Implemented **extended Kalman Filter (EKF)** and Extremum-Seeking control based active alignment control algorithm to maintain line of sight between transceivers of two robots moving in 3D space.
  - Demonstrated simultaneous tracking and communication (**STAC**) while transmitting information (images, commands) between two moving underwater robots using visible (Blue, 470 nm wavelength) light.
- **Face Recognition using Convolutional Neural Network** East Lansing, MI
  Mentor: Dr. Anil K Jain, Michigan State University *January 2017 - April 2017*
  - Created a CNN based face recognition system to identify faces from the LFW dataset
  - Trained an available CNN model on the CASIA WebFace dataset and evaluated it by extracting features on the LFW dataset and performing experiments according to the BLUFR protocol
  - Implemented LDA with resulted verification rate of 39% at false alarm rate of 0.1%
- **Control of LOS dependent dynamic switching networks** East Lansing, MI
  Mentor: Dr. Xiaobo Tan, Michigan State University *Sept 2015 - Dec 2015*
  - Modeled a network of robots, where a communication link between two robot nodes only exists when they are facing each other
  - Formulated a probabilistic framework to analyse the switching and rotation behavior of robots that follows on the Brownian motion
  - Implemented a polygonal formation control using network consensus algorithm

- **Meal Recognition, using Convolutional Neural Network** East Lansing, MI
  Mentor: Dr. Xiaoming Liu, Michigan State University *August 2016 - December 2016*
  - Designed and built a food item recognition system, which identifies the food items in an image
  - Implemented a CNN based network architecture to classify 16 food classes: pizza, apples, egg, etc
  - Designed the network using Python's Keras wrapper for Theano library
- **Wearable FSR-based Device for Monitoring Muscle Activity** East Lansing, MI
  Mentor: Dr. Xiaobo Tan, Michigan State University *Sept 2014 - Dec 2014*
  - Developed a body-worn device to sense actuation at multiple points of fore-arm muscle
  - Used a neural network in real-time to identify hand gestures from data transmitted via ZigBee
  - Demonstrated emulation of mouse clicks and key-presses that are mapped to different hand gestures
- **Voronoi Diagram Based Roadmap Motion Planning** Kanpur, India
  Mentor: Dr. Amitabha Mukherjee, Indian Institute of Technology Kanpur *January 2013 - April 2013*
  - Extended the Voronoi diagrams from point objects to polynomial objects
  - Implemented **Dijkstra's** graph search algorithm to find shortest collision free path between start-point and goal-point specified by a user
  - Developed a graphical user interface (GUI) on Matlab to draw polygonal obstacles and input desired start and goal points
- **Robotic Fish** Kanpur, India
  Mentor: Dr. Laxmidhar Behera, Indian Institute of Technology Kanpur *May 2011 - May 2013*
  - Designed and constructed a fish-like robot able to swim forward and turn using tails' swimming motion realized by a **3 joint cascaded servo mechanism**. For perception, it was equipped with infrared sharp sensors, an accelerometer and a Zig-bee wireless module to communicate with a PC
  - Fabricated a solid silicon rubber outer body using a series of manufacturing processes like Moulding, CNC turning and Rapid Prototyping using 3D printer
- **Projection System Adapted to Arbitrary Surfaces** Kanpur, India
  Mentor: Dr. Amitabha Mukerjee, Indian Institute of Technology Kanpur *Aug 2012 - Nov 2012*
  - Made a projector-camera system able to project undistorted images on non-planar surfaces like edge of walls, dome etc
  - The system is targeted to be used for projecting videos on **Concave Hemispherical Surface** of **India's first student's made planetarium** at IIT Kanpur
  - Projected binary encoded structured light images to get point to point mapping of original and projected images
  - Used **Delaunay Triangulation** to calculate **homography** matrix so as to get overall transformation of the projection geometry
- **Robust Design of Beamformer for loudspeaker Arrays** Kanpur, India
  Mentor: Dr.Rajesh Hegde, Indian Institute of Technology Kanpur *Jan 2012 - April 2012*
  - Simulated and modeled 16-element Loud-speaker array on Matlab
  - Implemented **Gradient Descent Optimization Algorithm** to **design** weights assigned to each loud speaker
  - System is able to focus sound in one area and reduces audibility in unwanted areas

Journal Articles

- **P. B. Solanki**, M. Al-Rubaiai, and X. Tan. Extended Kalman filter-based active alignment control for LED optical communication. *IEEE/ASME Transactions on Mechatronics*, 23(4):1501–1511, Aug 2018
- **P. B. Solanki** and X. Tan. A Bidirectional Active-alignment Control System for LED communication. *IEEE/ASME Transactions on Mechatronics, **(under review)***
- O. Ennasr, C. M. Holbrook, D. W. Hondorp, C. C. Krueger, D. Coleman, **P. B. Solanki**, J. Thon, and X. Tan. Characterization of acoustic detection efficiency using a gliding robotic fish as a mobile receiver platform. *Animal Biotelemetry*, 8(1):32, Oct 2020

Peer-reviewed Conference Proceedings

- P.B. Solanki, S.D. Bopardikar, and X. Tan. Active alignment control-based led communication for underwater robots. In *2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (**IROS**)*, pages 1692–1698, Oct 2020
- **P. B. Solanki**, S. D. Bopardikar, and X. Tan. A bidirectional alignment control approach for planar led-based free-space optical communication systems. In *2020 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (**AIM**)*, pages 1949–1955, 2020
- **P. B. Solanki** and X. Tan. Extended Kalman filter-based 3D active-alignment control for LED communication. In *2018 IEEE International Conference on Robotics and Automation (**ICRA**)*, pages 4881–4888, May 2018, Brisbane, Australia
- **P. B. Solanki** and X. Tan. Extended Kalman Filter-Aided Active Beam Tracking for LED Communication in 3D Space. In *Dynamic Systems and Control Conference (**DSCC**)*, 10 2017, Tysons Corner, VA. V002T04A009
- **P. B. Solanki**, M. Al-Rubaiai, and X. Tan. Extended Kalman filter-aided alignment control for maintaining line of sight in optical communication. In *2016 American Control Conference (**ACC**)*, pages 4520–4525, July 2016, Boston, MA
- **P. B. Solanki** and X. Tan. Experimental implementation of extended Kalman filter-based optical beam tracking with a single receiver. In *2016 IEEE International Conference on Advanced Intelligent Mechatronics (**AIM**)*, pages 1103–1108, July 2016, Banff, Canada
- A. S. Shree, V. K. Singh, **P. B. Solanki**, and L. Behera. Design and development of robotic fish swarm based coast monitoring system. In *Proceedings of Conference on Advances In Robotics*, (**AIR**) '13, page 1–6, New York, NY, USA, 2013. Association for Computing Machinery
- **P. B. Solanki**, S. Dutta, and L. Behera. Design and 3D simulation of robotic fish. In *Advances in Control and Optimisation of Dynamic Systems (**ACODS**)*, pages 1–8, September 2012, Bengaluru, India

Honors and Awards

- **Best Poster** 2018
  in the "Multi-agent systems" category at Midwest Workshop on Control and Game Theory
- **First runner-up** 2019
  in the 3 Minute Thesis *competition organized at Graduate Academic Conference MSU*
- **Winner** 2011
  of Wild Soccer *robotics competition at Techkriti, IIT Kanpur*
- **Winner** 2010
  of Bat-mobile Challenge *robotics competition at Takneek, IIT Kanpur*
- **Winner** 2010
  of Incognito *robotics competition at Techniche, IIT Guwahati*
- **Graduate Office Fellow** 2017
  Awarded by College of Engineering, MSU
- **Engineering Distinguished Fellow** 2015
  Awarded by College of Engineering, MSU
- **Best Project Work** 2013
  in the graduating batch of Bachelor of Technology in Electrical Engineering, awarded by IIT Kanpur for designing a prototype of Robotic fish
- **Academic Excellence Award** 2012
  Awarded by IIT Kanpur
- **National Talent Search Scholarship** 2007
  Awarded by National Council of Educational Research and Training, India

Graduate Coursework

- Linear Systems and Controls
- Nonlinear Systems and Controls
- Optimal Control
- Adaptive Control
- Networked and Embedded Control
- Stochastic Processes and Applications
- Computer Vision
- Patter Recognition and Analysis
- Detection and Estimation Theory
- Optimization for Engineering Design

Undergrad Coursework

- Signals, systems and networks
- Control systems Analysis
- Probability and statistics
- Introduction to Robotics
- Digital Signal processing
- Computer Vision and Image Processing
- Modern Optics
- Digital Electronics and Microprocessor Technology
- Applied Game Theory
- Artificial Intelligence Programming

Technical Skills

- **Programming and Tools:** Matlab, Python, C, C++,Version control (Git), Linux, Ruby on Rails, Latex
- **Robotics:** CAD Modeling (Solidworks, Inventor), PCB-Design (Eagle), Microcontrollers, Embedded Programming, Motors (DC, Brushless, Servo, Dynamixel, ESCs and driver), Sensors(IMU, photo-diode, IR, pressure), UART, I2C
- **Fabrication:** PCB design (Eagle), CAD Modelling (Solidworks), Welding, Lathing, Soldering, Machine Shop Safety

Professional Affiliations and Services

- IEEE Student Member, IEEE Robotics and Automation Society Student Member, ASME Student Member
- Reviewer for American Control Conference (ACC), IEEE/ASME International conference on Advanced Intelligent Mechatronics, IEEE/ASME International conference on Robotics and Automation, IEEE/RSJ International conference on Intelligent Robots and Systems, Journal of Dynamic Systems, Measurement and Control, IEEE/ASME Transactions on Mechatronics
- Session Chair: Control of Mechatronic Systems-II, Session Co-Chair: Design and Optimization in Mechatronics, Fault and Anamoly Detection at IEEE/ASME International conference on Advanced Intelligent Mechatronics 2020
- General Volunteer at IEEE/ASME International conference on Advanced Intelligent Mechatronics 2020 and American Control Conference 2021
- Volunteer at Dakshana Foundation, conducted entrance exam for Grand Dakshana Selection Test 2011 at Lucknow, India

Extracurricular Activities

- Member of MSU Triathlon Club 2018–Current
  -Competed at multiple Sprint and Olympic distance triathlons in the Midwest Area
  -Member of the MSU triathlon team at USAT Collegiate Nationals 2019 at Phoenix, AZ
  -Maintained the club website for the session year 2019-2020
- Sci-files Podcast Interview at IMPACT 89.5 FM Jan 2020
  -Appeared on university radio station IMPACT 89.5 FM *on the show* Sci-files*, hosted by Chelsie Boodoo and Daniel Puentes, the podcast is accessible* ***here***
  -Talked about my research on Underwater wireless optical communication
- Scuba Diving
  -Certified 'Open Water Diver' *from Scuba Schools Internationals (**SSI**)*
- Solving Rubik's Cube
  -Selected and participated in Cubing USA Nationals 2017, Fort Wayne, IA
  -Successfully solved the 3x3 cube blindfolded in Michigan Cubing Competition, 2016 at Ann Arbor, MI
- Member of Robotics Club and Robocon team of IIT Kanpur 2009-2011
  -The Team has bagged 7th position among 54 teams in Robocon India 2010 (at Pune, India) with Best Manual Operator Award
  -Designed and constructed autonomous robots that perform multiple articulated tasks: Wedge climbing, picking and placing of objects in a coordinated and synchronized manner